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13 August 1964

MEMORANDUM FOR: [redacted]

SUBJECT : Comments on [redacted] paper "Remarks on the Development of a High Resolution Reconnaissance System" dated 1 June 1964



1. The subject proposal and its appendixes were reviewed and analysed by five members of our staff having highly diversified technical backgrounds. The following comments are a composite of their thoughts on the subject.



2. Looking at the overall picture it is more those things which are left unsaid than what actually has been said that bothers the reviewers.



3. [redacted] claims to have a revolutionary new emulsion; however, quoting from Page 5, "it has not yet been possible to trade off its resolution for speed." This is an awfully big "exception". Molecular films such as Diazo or Horizon materials are not particularly new and they exhibit these very same characteristics -- ultra high-resolution but with low speed and inadequate gray scale. In fact, there is so little contrast range in some of these materials that they are not satisfactory as good reproduction materials let alone as an operational photographic medium. If, in fact, [redacted] has made some sort of break-through in obtaining a molecular grain size emulsion with reasonable speed, we are extremely interested. Nevertheless, if they have obtained (or can even approach) reasonable speed and contrast characteristics, they should be able to readily demonstrate this to our satisfaction on test specimens. In addition, they should be able to provide us with test materials, with which we can then duplicate their results. If they cannot provide this evidence then we have heard many other claims and seen other proposals similar to this one in the past.



4. We would like to be highly enthusiastic; unfortunately, past experience with other contractors' claims on molecular grain size materials has left us somewhat skeptical.

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4. Assuming the desired material does exist there are a number of other questions and problems that arise. Materials of 10,000 lines sound wonderful but they are not necessarily meaningful because of the restrictions imposed by the size of the wave lengths of visible light. We would have to look at the images with "exotic tools" such as, hard ultraviolet, x-rays or possibly through the use of electron microscopes. There appears to be a practical (not theoretical) limit at about 1000 to 1500 lines/mm; we currently require 400 to 600 line optics or better to look at 180 line materials in order to insure complete transfer of the low contrast information. This would indicate that we would need microscopes resolving 2500 lines/mm or better to look at 1000 line materials. Even then we would require oil emersion objectives (a problem with film). These are "sticky" problems but not unsolvable.

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5. Assuming such a high resolution film, it appears very logical to build ultra small cameras with microscope lenses as objectives since, as the author suggests, we can use exotic refractory elements such as, calcium fluoride. This material is currently used by [redacted] in their Fluotar objectives to obtain very high numerical apertures; however, the crystals are not large enough to be used in the construction of conventional camera lenses. In addition, it is true that microscope objectives have high N.A.'s and are highly corrected. At the same time there are things here left unsaid.

a. First, f/1 is about the limit for dry (non-oil emersion) objectives.

b. Lenses generally do not perform the same when used backwards. The lenses used for visual microscopy and those used for microphotography are usually quite different. When the eye is the integrating device, it actually looks at only one very small area or portion of the total field at a time. A camera looks at the total field all at once, therefore, the degree of optical correction required for visual viewing is generally not as high as that required for camera recording. For instance, the requirements for field flatness are not as stringent in a microscope as in a camera.

c. Generally, when a camera gets smaller, I.M.C. becomes less difficult to implement. This is true to a point; but, if the camera then passes this point and becomes ultra small, so that the I.M.C. motion moves down into the micron range it appears the problem becomes, conversely, extremely difficult.

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To make a minute, ultra precise motion-extremely fast-appears to be a fantastic problem. The precision required for ultra critical focus and the difficulty of first constructing, and then bending the film over a curved platen becomes considerably more difficult as the radium decreases.

d. As the resolution increases, "noise" from atmospheric scattering, etc., remains the same and therefore its magnitude in respect to the size of the objects resolved becomes greater, consequently the signal to noise ratio should be lowered. Moreover, as the displacement between images decreases (1000 l/mm plus) the dimensional requirements of the film and emulsion become more critical. The required emulsion would have to be molecularly thin and ultra-uniform (no waves). This appears to be a problem of considerable magnitude. These problems can, no doubt, be solved. They are only mentioned because the proposal treats them so lightly.



6. The system proposed for aspherizing the 1 meter mirror is neat, intriguing and perhaps feasible; however, if our attempts [redacted] contract) to accomplish aspherizing through thin film evaporative techniques are any indicators, this approach will be easy to describe in theory but extremely difficult to implement; nevertheless, the rewards would be great. Needless-to-say, if they can produce a 1 meter focal length f/1 reflective lens this would be a fantastic collection system even using more conventional films.



7. From a PI standpoint, the proposed system would present six major problem areas:

a. The viewing microscope problem already discussed.

b. The high-resolution would probably obviate the use of rear projection viewers as we know them.

c. It would present many obvious reproduction problems.

d. One really big problem would be locating, at that scale, what you want to look at.

e. The images would be so minute that the smallest particles of dust would be completely intolerable in any stage of the processing; processing, reproduction viewing (PI), measuring or storing of the film. In fact, all of NPIC would have to become a clean room.

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f. Such materials would require sub-micron comparators for mensuration.

8. It must be emphasized that none of these problems are really insolvable; however, should such a system be undertaken, it would require a considerable lead time and a massive equipment development program on our part. In effect, we would need practically all new exploitation equipment, "from the ground up".

9. Other than the obvious advantages of a small acquisition package the system would provide some definite PI advantages in that it is a natural for the chip approach, would reduce our storage requirements and decrease the size of the optical elements in our viewing systems.

10. If you believe it appropriate, we would be glad to evaluate samples of their photo sensitive material from an exploitation point of view, however, we will take no further action on this matter without instructions from you.

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Development Branch, P&DS